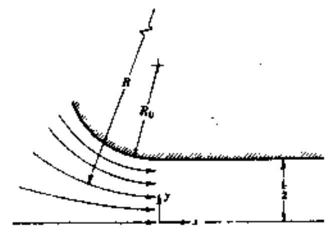
Problem 6.24

Given: Radius of curvature of streamlines at wind tunnel inlet is modeled as

$$R = \frac{h/2}{y} R_o$$

Speed along each streamline assumed constant at $V = 20\,m/s$; $h = 0.15\,m$, $R_o = 0.6\,m$.



Find: Δp between $y=0$ and tunnel wall ($y = h/2$)

Solution:

Basic equation: $\frac{\partial p}{\partial n} = \rho \frac{V^2}{R}$

Assumptions: (1) steady flow (2) frictionless flow
(3) neglect body forces
(4) constant speed along each streamline

At the inlet section, $p = p(y)$

$$\therefore \quad \frac{dp}{dn} = -\frac{dp}{dy} = \rho \frac{V^2}{R} = \rho V^2 \frac{2y}{R_o h}$$

$$\therefore \; dp = -\frac{\rho V^2}{R_o h} 2y\, dy$$

$$p_{h/2} - p_o = \int_0^{h/2} dp = -\frac{2\rho V^2}{R_o h} \int_0^{h/2} y\, dy = -\frac{2\rho V^2}{R_o h} \frac{y^2}{2}\Big]_0^{h/2}$$

$$p_{h/2} - p_o = -\frac{\rho V^2}{R_o h} \frac{h^2}{4} = -\frac{\rho V^2 h}{4R_o}$$

$$p_{h/2} - p_o = -1.225\,\frac{kg}{m^3} \times \left(20\,\frac{m}{s}\right)^2 \times 0.15\,m \times \frac{1}{4} \times \frac{1}{0.6\,m} \times \frac{N \cdot s^2}{kg \cdot m}$$

$$p_{h/2} - p_o = -30.6\ N/m^2 \longleftarrow \quad p_{h/2} - p_o$$